Experiments in Growing *Papaver bracteatum* Lindl.

U.S. Department of Agriculture
Agricultural Research Service
Agricultural Reviews and Manuals•ARM-W-25/April 1982

A copy of this publication is available upon request from the Western Regional Plant Introduction Station, Pullman, Wash. 99164.

International Standard Serial Number (ISSN) 0913-3760

Agricultural Research Service, Agricultural Reviews and Manuals, Western Series, No. 25, April 1982

Published by Agricultural Research Service (Western Region), U.S. Department of Agriculture, Oakland, Calif. 94612

ABSTRACT

Papaver bracteatum Lindl. is a perennial poppy native to the mountains of Iran and is a rich source of the alkaloid, thebaine. It is a source of many manufactured pharmaceuticals and can be a source of codeine. This study shows that *P. bracteatum* can be grown in the irrigated West with alkaloid levels near 3 percent in the deseeded, mature capsules. The plant has few insect or disease problems serious enough to affect capsule production. No increase in capsule yield has been obtained from fertilizer application in excess of 55 kg/ha nitrogen. The plant will tolerate highly calcareous soils, but is sensitive to sodium salts. Temperatures of -2°C will kill flower buds that are above the leaf canopy; stands were lost at -17°C during January without snow cover.

KEYWORDS: Alkaloids, capsule yield, codeine, diseases, fertilizer response, frost tolerance, Great Scarlet Poppy, gum production, insects, *Papaver bracteatum*, pollination, spider mites, thebaine.

CONTENTS

EXPERIMENTS IN GROWING *PAPAVER BRACTEATUM* LINDL.

By A. M. Davis[1]

INTRODUCTION

Papaver orientale L., *Papaver pseudo-orientale* (Fedde) Medw. (*Papaver intermedium* DC.), and *Papaver bracteatum* Lindl. are the three species that make up *Papaver* section Oxytona (Goldblatt *1974*)[2] and are known collectively as Oriental poppies in the horticultural trade. All three species are deep-rooted perennials with large showy blooms (fig. 1). *Papaver orientale* is the smallest of the three, with orange blooms and no mucros (petal spots). Stems are largely scapes (stalks) and leaves are primarily basal. This is the only species of the three that is a mat-forming, root spreader.

True *Papaver bracteatum* is large (more than 100 cm tall), with deep red flowers to 15 cm across, and well-developed, purple-black petal spots subtended by three to five coarse, serrate, conspicuous bracts. Leaves are basal rosette and cauline on the stem to within 15 to 25 cm of the flower.

The root system descends from a broad crown, and several roots (up to 1 cm thick) grow downward 2 m or more without appreciable diminution in root diameter (fig. 2). Spreading roots or rhizomes, a characteristic of *P. orientale*, is never present. Roots are semifleshy and do not penetrate hardpans. When an impervious layer is encountered, the root will "stub off" or, in some cases, grow laterally a short distance. If the impervious layer has a sodic accumulation, the roots will stub off and stop growing, but when the layer contains calcium, the root may run laterally. Roots have been followed laterally 1 m at a depth of 1.5 m.

The flowers of some *Papaver pseudo-orientale* biotypes vary from almost white with a pink cast to various shades of pink, salmon, orange, and red. Petal spots and speckling may be present. Most *P. pseudo-orientale* flowers, however, are shades of orange to deep red with varying degrees of petal spot.

---

[1]Research agronomist, U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS), Western Regional Plant Introduction Station, Pullman, Wash., 99164.

[2]The year in italic, when it follows the author's name, refers to Literature Cited, p. 26.

Figure 1.--General field view at peak bloom.

Figure 2.--Root system of a 3-year-old plant.

At the Central Ferry, Wash., research unit, all three species are dormant from mid- to late summer. After seed maturity, the plants dry and are senescent until cool weather. New growth is in the form of rosettes at each crown. They remain in this form until early spring, when rapid vegetative growth occurs. Four-year-old specimen plants of *P. bracteatum* and *P. pseudo-orientale* have measured over 1 m in spread and have produced over 40 flowers per plant.

Papaver bracteatum is a perennial poppy native to the mountainous region of Iran and surrounding countries. It is common in the Alborz Mountains south of the Caspian Sea and the Zagros Mountains (Kurdistan) near the border of Iran and Iraq. The Alborz Mountains contain mixed populations of *P. pseudo-orientale* and *P. orientale*, whereas the Zagros or western mountains largely contain populations of *P. bracteatum*. Collections with higher thebaine percentages (dry weight basis) came from the Zagros Mountains, particularly the Mahabad region. The earliest collection of *P. bracteatum* was received by the Plant Introduction System in 1972 and registered as PI 368264. It was presented by I. Lalezari of the University of Tehran. Sharghi and Lalezari (*1967*) reported that *P. bracteatum* from the Alborz Mountains was an extremely rich source of thebaine, comprising as much as 98 percent of the total alkaloids present in the plant. Alkaloids are present in the latex system similar to other Papaver species and concentrate in the capsules and roots at maturity.

Thebaine also occurs as a minor alkaloid in *Papaver somniferum* L. (opium poppy). It can be converted chemically to codeine and other pharmaceuticals. Codeine is a component in many prescription painkillers, cough suppressants, and other medicines in today's pharmaceutical arsenal. Although U.S. manufacturers refine and process codeine compounds, Asian and European countries supply the raw materials.

Papaver bracteatum is unique in that it produces thebaine, a little isothebaine, and some alpinigenine. The total amount of thebaine is often 98 percent of the total alkaloid complex present in the plant. This makes the probability of contaminated alkaloid very low. Thebaine is an alkaloid that can be converted to codeine without going through morphine. This allows the manufacture of the medically required codeine without producing the easily abused morphine. Thebaine is obtained as a minor alkaloid from the production of opium gum.

With the realization by Sharghi (United Nations *1973*) that *P. bracteatum* produced thebaine as the single major alkaloid, the United Nations Division of Narcotic Drugs became interested in the possibility of producing *P. bracteatum* as a source of codeine and getting away from the dependence on the opium poppy for all of the licit opium-derived drugs. The United States became interested in this plant as a possible new crop for American agriculture and as a source of locally controlled production of the medically required codeine. The commercial production of *P. bracteatum* had not been attempted and the practices needed to produce this new plant were not known.

Experiences in the production of *P. bracteatum* before 1972 had been limited to the efforts of Sharghi and his coworkers in Iran and a few botanical gardens and commercial seed producers who were selling the seeds as an ornamental. Through their efforts, several horticultural types had been developed. Most of these were *Papaver pseudo-orientale* and some were *Papaver orientale*. Deep redcolored flowers with deep purple petal spots were among the cultivars and selections offered the general public. These proved not to be the true *P. bracteatum* but *P. pseudo-orientale*.

During the early period of ARS involvement in the attempted development of *P. bracteatum* as a new crop for American agriculture, a worldwide shortage developed of the medically required phenanthrene[3] alkaloids. This gave strong positive stimulus to the development of alternative sources of required licit narcotic drugs. From 1973 through 1979, active investigation of this plant was carried out at several locations in the United States by the USDA, State Agricultural Experiment Stations, and several pharmaceutical companies, which contributed a major part of this effort. As of this writing, the production of thebaine as a source of licit narcotic drugs has not been legalized, and the production of *P. bracteatum* is limited to an occasional ornamental plant.

The first seed lots of *Papaver* (section Oxytona) received by the Western Regional Plant Introduction Station, Pullman, Wash., were a mixed collection. All of it was originally considered to be *P. bracteatum*, but upon growing the plants to maturity it was apparent that several species were present: *P. bracteatum*, *P. pseudo-orientale* (*P. intermedium*), and *P. orientale* (Appendix table 1). Some accessions presented in Appendix table 1 were mixture of *P. pseudo-orientale* and *P. bracteatum*. The accessions presented in Appendix table 1 as *P. pseudo-orientale* but in Appendix table 2 as *P. bracteatum* were predominantly *P. pseudo-orientale*, thus the characterization. The plantings recorded in Appendix table 2 had the *P. pseudo-orientale* component rogued out, leaving only true *P. bracteatum* in this trial.

All plantings, except as specifically noted in this report, were grown at Central Ferry, Wash., located approximately 46.7° north latitude and 117.8° west longitude at an elevation of 195 m above mean sea level on an alluvial bar of the Snake River.

Most of this early planting was of the *pseudo-orientale* type; many of the seeds had been collected from commercial sources, herbaria, and seed companies. These were the sources of the more showy, longer-blooming types. Chromosome counts have not been made on these accessions, but *P. bracteatum* has 2n = 14; *P. pseudo-orientale*, 2n = 42; *P. orientale*, 2n = 28 (United Nations *1973*, Goldblatt *1974*).

Appendix table 1 indicates the combinations of five observable characters and the variations among them that were present in this early collection.

---

[3]Generic term for family of chemicals that includes codeine, morphine, thebaine, and many other alkaloids.

EVALUATION OF PAPAVER BRACTEATUM BIOTYPES

A collection of 188 accessions was established by translating 10 plants per accession in March 1975 at Central Ferry. These were harvested each year in July by hand-snapping the capsules at the collar. The capsules were counted, dried, and weighed. The capsule tissue was separated from the seeds, ground, and analyzed by the gas/liquid chromatographic method (GLC) presented in U.N. Document ST/SOA/Ser.J/15 (*1974*). This was repeated for 1976, 1977, 1978, and 1979.

The GLC used in these studies was a Tracor model 560, equipped with autosampler, a Spectro-Physics integrator, and a Shimadzu strip chart recorder. Appendix table 2 presents the results of this 4-year study.

Each year's results were different due to field management and weather. The winter of 1975-76 was relatively mild, with good fall and winter precipitation. Irrigation was provided by sprinklers from March through maturity, that is, mid-June. The plants were vigorous and productive. The highest per plant yield of capsule tissue occurred this first year, and even though the thebaine percentage (dry weight basis) was not as high as in later years, the total yield of thebaine per unit area was higher than in succeeding years.

Plant height varied from 58 to 105 cm with most plants in the 75- to 85-cm range. Plant height, capsule count, capsule size, thebaine percentage, or total thebaine per unit area were not positively related. The tallest accessions were only average for the measurement criteria.

In 1976, the first year of production, capsules per plant ranged from 2.7 in plant introduction (PI) 381450, and PI 381456 (short, low-vigor accessions) to 12.9 for PI 381495, with the majority producing 8 to 10 capsules. In 1977, the second year of capsule production, plant stresses imposed by fall and winter drought reduced capsule yield. Accessions averaging less than one capsule per plant were PI 381453, PI 381475, PI 381477, PI 381481, PI 381482, PI 381483, PI 381518, PI 381525, PI 381537, PI 381563, PI 381576, and 381581, whereas PI 381492 averaged 14.4 capsules per plant, one of the few accessions that produced more capsules per plant in 1977 than in 1976.

The field-dried capsules (fig. 3) were hand-snapped from the standing dry stalks and were put through a hammermill with 1/2-inch screens. Seeds were removed by using a shaker screen, and the remaining capsule tissues were stored in kraft paper bags in a dry closet at 6 to 8 percent moisture and 20° to 22°C until analysed. Analyses were completed within 180 days after harvest.

The collection made in Iran by Peter Goldblatt (PI 381000 series) was planted in 1975; therefore, 1976 was the first production year. Some superior lines, with a high number of capsules of good individual size and at least average thebaine content, were identified on the basis of the first-year results.

The lines listed in table 1 had 10 or more capsules per plant with 2 percent thebaine or more and average capsule weight of 3 g or more in 1976. The accessions numbered 381487 through 381497 were collected at a single site near Saqquez, on the road to Marivan. The other accessions were collected from

Figure 3.--General field view at beginning of bloom.

various sites throughout western Iran. These accessions continued to exhibit general superiority throughout the 4 years they have been grown at Central Ferry shown in table 1.

Table 1.--*Performance of 15 superior* Papaver bracteatum *plant introductions (PI) grown from 1976 to 1979*

PI accession No.	Capsules per plant				Thebaine				Average weight per capsule			
	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
	Number				*Percent*				*Grams*			
374719	14.8	6.8	17.5	13.9	2.1	2.1	1.9	1.9	3.2	1.4	1.4	1.4
381438	10.6	5.2	15.2	15.0	2.3	2.4	1.7	1.7	3.3	2.0	1.4	1.3
381442	12.7	9.8	15.7	17.6	2.0	2.5	1.3	2.0	3.9	1.9	1.5	1.6
381444	13.3	8.3	16.8	15.6	2.2	2.1	1.9	1.9	3.7	1.3	1.3	1.6
381457	10.1	3.5	20.2	17.3	2.2	2.6	1.7	1.7	3.8	1.3	1.6	1.9
381487	10.9	3.0	11.7	11.7	2.9	3.7	2.1	2.3	3.6	1.2	1.1	1.7
381488	12.0	7.3	12.7	12.6	3.6	---	2.4	2.1	3.3	1.7	1.4	1.8
381490	11.3	8.3	14.1	12.1	2.2	2.2	1.9	1.9	3.8	1.2	1.4	1.9

Table 1.--*Performance of 15 superior* Papaver bracteatum *plant introductions (PI) grown from 1976 to 1979*--Continued

PI accession No.	Capsules per plant				Thebaine				Average weight per capsule			
	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
	Number				*Percent*				*Grams*			
381492	13.6	14.4	16.0	15.7	2.5	2.4	2.5	2.7	3.9	1.4	1.5	1.7
381493	11.4	2.7	10.1	11.1	2.0	2.2	1.7	1.7	3.9	1.6	1.7	1.7
381494	11.4	2.5	10.2	12.3	2.4	2.2	1.6	1.2	3.8	1.3	1.5	1.6
381495	12.9	3.6	12.1	11.9	3.2	3.5	1.5	2.8	3.5	1.7	1.3	1.5
381497	10.0	2.7	13.4	11.8	4.2	1.7	2.1	2.3	2.8	.8	1.1	1.5
381502	11.0	9.3	13.8	12.8	2.7	1.3	1.7	1.5	3.5	1.9	1.4	1.5
381534	11.4	6.4	13.6	10.1	2.3	2.1	2.0	---	3.5	1.4	1.1	1.3
Average	11.7	6.1	14.4	13.5	2.6	2.3	1.9	2.0	3.5	1.4	1.3	1.6
S.D.	1.3	3.2	2.5	2.2	.6	.6	.3	.4	.3	.3	.2	.2
C.V.	11.4	53.3	18.2	16.7	23.1	25.9	16.8	20.6	8.3	23.1	12.2	11.0

Note: Dashes indicate missing data.

STABILITY OF THEBAINE IN STORAGE

Thebaine was stable in storage under dry, room temperature conditions. Capsule tissues from the 1976, 1977, and 1978 harvests were analyzed in April 1979; the results are shown in table 2. Each value is the average of three subsamples from the same 5- to 8-kg storage sample.

Table 2.--*Thebaine percentage at harvesttime compared with its amount after extended room temperature storage as coarse ground seed-free capsule tissue from 6 selected plant introductions (PI) of* Papaver bracteatum

PI No.	Thebaine at harvest and after various storage periods			
	Harvest	10 months	22 months	34 months
377953	2.80	2.81	2.95	2.16
378940	2.67	2.59	2.85	2.06

Table 2.--*Thebaine percentage at harvesttime compared with its amount after extended room temperature storage as coarse ground seed-free capsule tissue from 6 selected plant introductions (PI) of* Papaver bracteatum--(continued)

PI No.	Thebaine at harvest and after various storage periods			
	Harvest	10 months	22 months	34 months
381600	2.90	2.93	3.30	2.26
381607	2.30	2.49	2.52	2.38
383309	2.87	2.49	2.88	2.25
391687	2.65	2.65	2.55	2.10
Mean	2.70	2.65	2.94	2.20

Plots were harvested during the first 2 weeks of July each year. Therefore, the 1976 tissue was stored 2 years and 10 months; 1977, 1 year and 10 months; and 1978, 10 months. The 1977 tissue was slightly higher in thebaine than the 1976 or 1978 harvests for all material analyzed.

This limited loss of thebaine after up to 34 months of storage is not true of finely ground capsule tissue, which had some seeds clinging to the placental tissue at the time the capsules were ground. During grinding, the broken seeds release oil and other oxidants that contaminate the capsule tissue and results in rapid loss of thebaine. To evaluate this potential hazard, we conducted the following trial.

Five grams of seed-free, capsule tissue of PI 381607 was ground and served as the base reference. In a second sample, seeds were added during the grinding process and were thus thoroughly distributed in the ground capsule material. Table 3 illustrates the effect of ground seed and storage time on the percentage of thebaine in the sample. These seed amounts are similar to those found in the mature capsule (26 to 35 percent seed by weight; most lines average 30 to 32 percent seed).

Table 3 shows that finely ground tissues do suffer some thebaine deterioration, but this loss is accelerated when seeds are ground with the capsule tissues. If any ground seed is present, extraction of the alkaloids should be completed immediately to minimize thebaine loss.

Table 3.--*Thebaine percentage from finely ground tissue of* Papaver bracteatum *plant introductions (PI) with and without ground seeds after different lengths of storage*

PI No.	12/8/75	12/31/75	1/22/76	2/17/76	3/20/76
381600	3.82	3.64	3.16	3.12	3.15
381605	2.66	3.16	3.23	2.42	2.18
381607	3.64	3.76	3.55	2.76	2.18
381607[1]	3.48	3.38	3.42	2.45	1.99
381607[2]	3.65	--	2.37	2.00	1.66
381607[3]	3.46	--	2.03	2.00	1.62

[1]Plus 1 g seed.
[2]Plus 2 g seed.
[3]Plus 3 g seed.
Note: Dashes indicate missing data.

We applied the following treatments to determine the effects of moistening and drying on whole seed-free capsules of PI 381600: Capsules were (1) autoclaved at 1.1 kg/cm^2 for 15 min; (2) soaked in distilled water for 1 hr; and (3) placed in a 100-percent saturated (22°C) atmosphere for 48 hr. Each was drained of free water and dried on the laboratory table for 36 hr, then placed in a thermal draft oven at 75°C for 12 hr. The soak water from treatment 2 was retained and analyzed for thebaine. The treated as well as untreated reference capsules were ground to 20 mesh fineness and immediately analyzed by using the GLC procedures of U.N. Document ST/SOA/Ser.J/15, 1974. The effect of these various moisture regimes on percent thebaine stability is as follows:

Treatments of PI 381600	*Percent thebaine stability*
Freshly ground capsule	3.92
Autoclaved (1.1 kg/cm^2) 15 min	3.56
Soaked 1 hr	3.07
Soak water (based on capsule dry matter)	.52
Humidified 48 hr	3.91

To estimate the effect of repeated summer-type showers on the thebaine stability in mature standing capsules, we applied overhead sprinkler irrigations of 0.6 cm of water four times during a 10-day period. Capsule samples were randomly taken from each set of plots before the first water application. Both sprinkled and unsprinkled plots were sampled after each sprinkler treatment. Two to four days elapsed between water applications. No measurable thebaine was lost; therefore, if mature capsule harvest should be interrupted by showers, no serious loss of thebaine is likely to occur. The rigidity of the stems and the overtopping of the capsule by the stigmatic caps effectively gives each capsule a canopy, preventing water from entering the capsule through the seed ostioles.

PLANT RESPONSE TO ENVIRONMENTAL STRESS

The winter of 1976-77 was particularly dry, with only 2.25 cm of precipitation during October, November, and December. Of this total, 1.68 cm fell in December. Normal precipitation for this period is between 11 and 12 cm. Fall growth of the poppies was severely reduced. Because fall irrigation was not provided and the plants were severely stressed, few primordia formed and spring growth was slow to begin. Sprinkler irrigation was started in March and soil moisture was brought to near field capacity throughout the remaining spring and summer growing season. This irrigation failed to compensate for the shortage of moisture in the late summer and early fall. Under our conditions, *P. bracteatum* needs vigorous fall growth to produce well the following year. Adequate moisture, either from natural precipitation or irrigation, must be provided during this active growing period of its life cycle.

In 1977-78, the plants were thoroughly irrigated in the fall, good growth subsequently developed in the spring, and no further irrigation was applied. These plants matured on residual winter moisture and natural spring precipitation (7.8 cm during March, April, May, and June). Owing to the presence of massive foliage and heavy bud formation, we thought that placement of irrigation sprinkler pipes in the field would be potentially more hazardous than reliance on natural precipitation. This proved to be a fallacious assumption. As the plants fruited and matured, additional water was needed to produce satisfactory yields. The number of capsules per plant in 1978 was almost without exception greater than the number produced in 1976 or 1977. The individual capsule weight was slightly greater than 1977 but less than 1976. These 1978 stressed plants failed to reach the level of capsule development observed in previous years. Adequate moisture must be available throughout the whole growing season, fall, spring, and summer, to maximize capsule dry weight yield per unit area.

Thebaine percentage in the capsule tissue was highest in the stressed year of 1977, lowest in 1976 when the plants were young and vigorous, and intermediate in 1978 and 1979.

Thebaine production per unit area is the final measure of potential value. Based upon thebaine percentage and capsule tissue production, we found that estimated yields of 40 kg/ha or more could be obtained in 1976 from the accessions listed in table 4. This level of thebaine production was not reached in succeeding years.

Table 4.--*Thebaine production by plant introduction (PI) accessions of* Papaver bracteatum *that produced 40 kg/ha or more of thebaine in the first production year*

PI No.	1976	1977	1978	1979
	Kg/ha			
381487	48.8	3.9	16.1	18.0
381488	51.1	1.7	23.2	8.6
381492	47.4	---	35.5	24.3
381495	54.7	4.6	13.4	17.1
381497	46.0	---	19.1	14.5
381528	48.4	---	10.1	7.2
381535	40.0	7.3	16.8	10.5

Note: Dashes indicate missing data.

The highest calculated thebaine yield in 1977 was 15 kg/ha from PI 381597, less than one-third of the yield of the highest accession in 1976. In 1978, a general improvement in yield was obtained even though no accessions produced the equivalent of 40 kg/ha. Three exceeded 30 kg/ha, PI 374839, PI 374854, and PI 381492. PI 381492 produced thebaine at a calculated rate of 35.5 kg/ha in 1978 and 24.3 kg/ha in 1979. It was the highest overall producer in the collection. It was collected in the Mahabad region of western Iran and is undergoing increase.

STAND ESTABLISHMENT AND MANAGEMENT

Stand establishment by direct seeding, with a vegetable drill and a carrot plate with half the holes plugged, has been successful in both spring and fall at Central Ferry. Spring seeding in March, or as soon as a seedbed can be prepared, has been superior to fall seeding even though volunteer seedlings become established every fall with the first rains. The seed is small (120,000 seeds per ounce or 4,200 per gram), and has limited emergence energy. Any degree of soil crusting or surface compaction forms an almost insurmountable barrier to emerging seedlings.

Most established plants remain in the rosette stage for one full growing season, but some early fall-established seedlings will form stems and produce normal flowers (usually only one per plant) the following summer. Floral initiation can be detected in late February; the growing point is deep within the crown, usually 2 to 3 cm below ground line.

FIELD MANAGEMENT

After capsule harvest, the standing residue was shredded with a rotary mower and the entire field, including poppy rows, was rototilled to a depth of 12 to 24 mm. This leaves a smooth field, controls weeds, and does not damage the established poppies. During the summer dormant period, no irrigation was applied. In late August, the plots were treated with diuron (3-(3,4-dichlorophenyl)-1, 1-dimethylurea), a preemergent herbicide, to control volunteer poppy seedlings and fall weeds. Application of 1.7 kg active ingredient in 187 L of water per hectare has given almost perfect control of poppy seedlings. Effectiveness of this herbicide is improved if a rain or light sprinkler irrigation occurs soon after application.

PLANT RESPONSE TO DATES OF FALL TRANSPLANTING

Fall transplanting of established seedlings has been successful, and flowers were produced the following season. Early transplanting on September 3 (90-day-old seedlings) was superior to the subsequent transplanting dates of October 5 (120-day-old seedlings) and November 6 (150-day-old seedlings). All plants survived and grew well the following year. All of the September-transplanted plants flowered the following year, with an average of 2.3 flowers per plant. Only 4 of 20 of the October transplants flowered. None of the November transplants flowered the following year. Transplanting conditions were far from ideal when the November transplants were made. The soil froze and thawed diurnally, but poppy seedlings transplanted under such conditions displayed a hardiness and an ability to survive adverse environments.

CHRONOLOGY OF PLANT GROWTH FROM SEEDING AT CENTRAL FERRY

Stands have regularly been established by spring seeding as soon as the soil reaches 13°C. This usually occurs in March. Spring seeding permits emergence and establishment with residual winter moisture, thus overcoming the need for irrigation and the resulting soil crusting that frequently occur with sprinkler irrigation. These plants grew until midsummer when they became dormant. This estival period is a natural physiological process and cannot be overcome with irrigation. Regrowth begins in September or early October at Central Ferry. The plants grow vigorously as long as temperatures are above freezing and soil moisture is available. All plants remain in the rosette through the fall and winter. Frost will desiccate the outside leaves of the rosette, but growth occurs during any extended warm period in the winter. Vigorous spring growth begins when temperatures begin to warm, usually in late February at Central Ferry. Rapid growth takes place throughout the spring, with vigorous stem elongation in late April and early May. Blooming begins in mid-May with the peak bloom occurring the third or fourth week of May and is nearly complete by the second week of June. Capsules are dry and mature by the first week of July, at which time the entire plant becomes summer dormant; all leaves and stems are dry and brown. The regrowth cycle begins again in September with a new rosette of foliage produced in the fall and winter.

PESTS

The primary pest at this location has been the twospotted spider mite, *Tetranychus urticae* Koch. This mite builds to epidemic populations on *P. bracteatum*. The large, vigorous winter rosettes of foliage provide an excellent overwintering site and a succulent food source during spring and early summer. The poppy possesses an unexpected tolerance to these pests. At maturity, large, webby masses of spider mites are present. This presents a greater potential problem for adjacent crops. As the poppies go into summer senescence, the spider mites must move to new feeding sites, so adjacent succulent growing green crops are subject to attack in epidemic proportions.

Pocket gophers (*Thomomys talpoides*) will eat the roots, and uncontrolled populations can seriously damage an established stand.

DISEASES

Once *Papaver bracteatum* is established, the stand is almost disease free. Some root and crown rots (caused by *Rizoctonia* sp.) have been observed, and seedling damping-off (caused by *Pythium* sp.) has occurred. Neither organism has been serious enough to affect the establishment of a full stand or damage more than an occasional plant after establishment. An occasional blue-stained mature capsule has been seen, and *Dendryphion penicillatum* Har. et Br. was isolated from the stained capsule by W. J. Kaiser (personal communication). This fungus has caused seedling damping-off, leaf and stem lesions, and stained capsules. It does not appear to be host specific and has been found on the wild, or corn poppy, *Papaver rhoeas* L., which grows in the Pacific Northwest. It caused no difficulties with stand establishment from either transplants or on direct-seeded plants.

RESPONSE TO HERBICIDES

To eliminate the possibility of any herbicidal effects on these plantings, all weed control was by conventional cultivation and hand hoeing. During the course of these investigations, we determined that *P. bracteatum* will tolerate low dosages of 2,4-D amine with only limited visible effects. Applications to the surrounding wheat fields and resulting drift have resulted in some peduncle kinking (S-shaped) but no obvious effects on flower development or thebaine production in the capsule has been detected. An established stand of *P. bracteatum* is difficult to eliminate by conventional tillage, that is, plowing and field cultivating. The resistance to phenoxy herbicides indicates a harsher treatment is required. Picloram (4-amino-3,5,6,trichloropicolinic acid), dicamba (3,6, dichloro-*o*-anisic acid), and glyphosate (*N*-(phosphonomethyl)glycine), have been succcesful. Picloram and dicamba are soil persistent, and if cropping is to follow, these should not be used. Glyphosate is not soil persistent, but repeat treatments of scattered survivors may be required.

PLANT POPULATION STUDIES

In April 1974, a direct-seeded plot was established with row widths of 45-, 61-, 76-, 91-, 106-, and 122-cm spacings. Within these row spacings, plants were thinned to a plant every 8, 15, 23, or 30 cm within the row. A single uniform application of ammonium nitrate at the rate of 56 kg/ha was made each succeeding March.

Evaluation of data indicates little difference after the first year's production from plant spacings. As plants mature, crown expansion overcomes the advantage of close spacings and high initial plant populations. Sustained higher thebaine yields were obtained with plant populations of 54,000 plants per hectare or more.

Thebaine production, averaged across years for each accession and row spacing, is presented in table 5.

Table 5.--*Calculated thebaine production from 3 plant introductions (PI) at 6 row spacings*

Plant spacing (cm) between rows	PI 381600	PI 381605	PI 381607
	Kg/ha		
45	20.9	11.6	14.8
61	21.7	10.6	15.6
76	21.4	10.8	15.6
91	15.8	9.3	13.2
106	17.2	9.7	13.8
122	17.4	9.0	12.4

Table 6.--*Calculated thebaine production from 3* Papaver bracteatum *plant introductions (PI) established at 4 within-the-row spacings*

Plant spacing (cm) within the row	PI 381600	PI 381605	PI 381607
	Kg/ha		
8	17.5	9.1	14.8
15	17.7	9.4	14.4
23	16.5	11.0	15.5
30	19.1	10.4	14.4

The superiority of PI 381600 over the other two accessions with row spacings of 61 to 76 cm is illustrated. The results of plant spacings within the row have been erratic and no clearcut advantage has been shown (table 6).

In the first year (1975), the higher thebaine yield per unit area came from the 8-cm plant spacing and the 45-cm row spacing. After the plants grew for 3 years, the differences between plant spacings was largely overcome.

Seed-free capsule yield from the plant populations study is presented in table 7. Capsule yield the first year was low, but the second year's (1976) yields were very good, with an average of 1327 kg/ha. This agrees with the higher yields of capsules and thebaine obtained in the genetic strain study where the higher production also occurred in 1976.

The fall, winter, and spring of 1975 were warmer than average. Other than one night in February (-9°C), the lowest temperature for each of the winter months was -8°C. Precipitation was above average, and a heavy irrigation was made in late October to put the plants in good condition for winter development. These conditions, plus the fact that all plants were young, and young plants in their first year of bloom have characteristically larger capsules than in succeeding years, combined to produce outstanding yields. This supports the feeling of some workers that the plant should be treated as an annual; that is, established each year and not carried over and harvested as a perennial.

SOIL FERTILITY STUDIES

A small pilot study was set up with PI 378940 transplants and a base overall nitrogen application of 56 kg/ha. Previous experiences at the location had indicated that about 56 kg/ha nitrogen was required to get normal plant growth of nonnitrogen fixing plants, and this was selected as the base application rate for nitrogen. Additional nitrogen was applied at rates of 112 and 168 kg/ha. Phosphorus was added at 0, 112, and 224 kg/ha P_2O_5 equivalent as triple superphosphate, and potassium was added at 0, 28, and 56 kg/ha as muriate of potash. These treatments were applied singly and in all combinations.

The soil at Central Ferry was classified as Spofford silt loam (fine-silty, mixed, mesic typic Natrixerolls). Standard soil tests made by the Soil Testing Laboratory, Washington State University, Pullman, on 10 samples taken in the plot area showed: pH, 6.5 to 6.8; organic matter, 1 to 1.9 percent; phosphorus, 21 to 31 p/m; calcium, 7 to 10 meq/100 g soil; and total salts, 0.60 to 1.50 mmhos/cm.

No yield differences have been observed from fertilization beyond 56 kg/ha nitrogen. The pilot study has been continued with annual applications as side dressing, at the same rates, since 1975. The first harvest was made in 1976.

When we applied the 5-percent estimation test of the mean ± 2 standard deviations (Snedecor *1956*), we found no values that exceeded this statistic for capsule number, capsule weight, or thebaine percentage. The basic needs of the plant for nitrogen appear to be met with 56 kg/ha on soils with the fertility characteristics of Spofford. Some delayed fall emergence has occurred after 5

Table 7.--*5-year summary of plant population study (in kilograms per hectare of seed-free capsules) of accessions of* Papaver bracteatum

Spacing (cm)	PI 381600					PI 381605					PI 381607					
	1975	1976	1977	1978	1979	1975	1976	1977	1978	1979	1975	1976	1977	1978	1979	Average
								Row spacing								
								Kg/ha								
Between rows:																
45	358	1524	659	457	534	236	1853	528	442	406	190	1394	574	462	374	666
61	320	1510	599	566	469	360	1475	468	453	351	367	1473	399	470	307	632
76	331	1496	629	511	509	425	1430	406	442	571	315	1436	492	486	423	660
91	236	1130	441	389	317	313	1244	445	319	364	300	1158	439	411	416	528
106	210	1204	490	482	485	348	1143	483	448	490	276	1169	389	472	454	569
122	336	1132	489	453	559	307	1070	413	462	371	276	1049	372	473	414	505
Average	298	1334	552	476	479	331	1369	457	427	425	288	1279	444	463	398	593
								Plant spacing								
Within rows:																
8	280	1431	588	631	462	446	1427	389	504	459	382	1344	460	497	391	648
15	253	1175	537	484	454	345	1198	382	434	411	299	1302	423	499	410	544
23	204	1060	497	526	396	280	1490	506	490	476	333	1380	500	508	483	608
30	241	1273	594	532	492	315	1291	500	503	485	200	1091	612	618	490	615
Average	244	1234	554	542	451	346	1351	444	482	458	303	1279	499	527	443	604

years of annual applications of the 56 kg/ha of potasium from muriate of potash. In fact, at this rate, additional potasium may produce a deleterious effect on total capsule yield.

A second series of plots was established by direct seeding in 1976 to compare ammonium nitrate and ammonium sulfate as nitrogen sources. A gypsum treatment was included as a source of sulfur and a limited pH adjuster.

Treatments were 0, 112, 224, and 336 kg/ha nitrogen from NH_4NO_3 replicated three times in addition to the uniform application of 56 kg/ha nitrogen from NH_4NO_3, and 112, 224, and 336 kg/ha nitrogen from $(NH_4)_2SO_4$. A companion study (also in three replications) consisted of 56 and 224 kg/ha nitrogen from NH_4NO_3 and 224 kg/ha nitrogen from $(NH_4)_2SO_4$, 112 and 224 kg/ha of P_2O_5 from 0-45-0 gypsum at 1121 and 1800 kg/ha. These same treatments were repeated in 1977, 1978, and 1979. Plants from plots receiving gypsum produced the least seed-free capsule tissues. The plants from the highest gypsum level plots yielded the least, whereas plants from the phosphorus plots with 56 kg/ha nitrogen produced the most seed-free capsule tissues in the test. These trends were not statistically significant at the 5-percent level of probability, but did exceed the 10-percent level (Snedecor *1956*). Overall average yield was 781.8 kg/ha seed-free capsules and a thebaine yield of 19 kg/ha at 2.5 percent thebaine.

In the NH_4NO_3 versus $(NH_4)_2SO_4$ comparison, $(NH_4)_2SO_4$ showed an advantage in both number of capsules per plant and subsequent total weights of capsule tissue per plant. Translated into a calculated yield of thebaine per hectare, the advantage was 1 kg/ha for the sulfate form of nitrogen (22.8 kg/ha from NH_4NO_3 and 23.8 kg/ha from $(NH_4)_2SO_4$). Differences in thebaine production for 1977, 1978, and 1979 were not significant at the 5-percent level of probability (Snedecor *1956*).

THE EFFECT OF CAPSULE MATURATION ON THEBAINE

Studies with immature and green poppy capsules were undertaken to determine whether an immature stage contained more thebaine than mature dry capsule tissue. Drying at 80°C overnight in a convection draft oven gave only very low thebaine values. Freeze drying was the indicated procedure, but an apparatus was not available and microwave drying was substituted. Subsequently, capsules were split longitudinally and each half was weighed.

One half was dried in a microwave over and the other half was macerated in a blender, immediately extracted, and analyzed by the procedures outlined in UN Document ST/SOA/Ser.J/15, 1974. The microwave ovendried tissue was dry in about 6 min. It was ground to pass a 0.5-mm screen and analyzed by the same procedures as the fresh tissue. When both procedures were converted to a dry weight basis, the outcomes were indistinguishable at 2.6 percent thebaine.

Overnight oven drying at 80°C and analysis by the same procedures showed that up to 74 percent thebaine can be lost by conventional slow oven drying. A small batch microwave ovendrying trial consisted of 35 g of longitudinally split capsules plus 5 cm of peduncle dried in the oven, while a companion batch of 35 g of split capsules and peduncles was extracted in a blender. In this small batch, the agreement between the microwave ovendried and the fresh tissue was very good at 2.54 percent thebaine corrected to dry weight basis. Apparently, an enzyme system destroys much of the alkaloid in the latex during slow drying, much as the enzyme system in alfalfa destroys carotene during slow drying and exposure to bright sunlight (Silker et al. *1944*).

In a planting of PI 378940, in 1977, random harvests of 25 capsules were made on June 6, 11, 19, 24 and July 1 and 8. Peak bloom occured on June 3, seed was harvested July 10, and the following thebaine levels were noted:

Collection date	*Percent thebaine (dry matter)*
June 6	2.8
11	2.4
19	1.7
24	1.8
July 1	1.9
8	2.5

The capsules were harvested green and immediately dried in a microwave oven on each harvest date except those harvested on July 8. These were matured and dry in the field.

When seeds were free in the open capsule, they were not included in the tissue preparations. Seeds turned brown about 28 days from bloom and, upon capsule drying, freely separated from the placental tissue. Only seed-free capsule tissues were collected on June 24 and July 1 and 8. The other samples contained seeds in varying stages of maturity.

Owing to the small amount of dry matter present during the early development period, even the relatively high thebaine percentage of 2.8 percent is not meaningful. Ovaries at bloom contained 50 to 75 mg dry matter and mature capsules weighed from 1 to 2 g. As the capsules grew to full size and seeds matured, the dry matter content increased and the alkaloid percentage decreased. At maturity, when dry matter was highest, the alkaloid (dry weight basis) almost reached the bloom stage level, and the total thebaine per capsule increased more than tenfold.

A second study, with PI 381600 plants, undertaken to determine the thebaine content based on the age of the capsule from date of bloom, provided the following results:

Age of capsule (days from flowering)	*Percent thebaine (dry matter)*[1]
3	3.3
6	3.2
8	2.5
11	2.2
13	2.1
16	2.2
17	1.7

Age of capsule (days from flowering)	*Percent thebaine (dry matter)*[1]
(continued)	
21	1.8
23	1.6
26	1.8
31	1.9
35	2.1
40	2.2
42	2.2
45	2.2
49	2.3

[1]Average of 2 samples of 10 capsules each.

Each flower was tagged and dated on the day of bud opening. Sampling was begun the third day from bud opening, because at this stage of development petal fall is usually completed. Capsules were harvested, taken to the microwave oven (less than 5 min elapsed), and dried as previously described. Capsules from flowers that bloomed before May 15 (capsules had a longer maturation period) usually had higher total thebaine than capsules from flowers that bloomed toward the end of May. Capsules dry uniformly as the whole plant matures.

THE EFFECT OF FERTILIZER APPLICATIONS ON THEBAINE YIELD AND THE RESPONSE TO CRITICAL WINTER TEMPERATURE FOR SURVIVAL

In mid-April 1976, five genetically diverse strains were established at Warden (46.5° N, 119.1° W, at an elevation of 360 m) in the irrigated region of the central Columbia Basin. Six hundred 90-day-old seedlings (120 of each strain) were hand transplanted in preirrigated soil. Adjacent rows were direct seeded to the same strains so comparisons of transplants and direct seeding could be made.

After emergence and seedling establishment, rows were thinned to the same populations as the adjacent transplanted plots. The plot was furrow-irrigated as needed in the fall, spring, and summer. Row spacings were 91 cm and 30 cm between plants for a population of 35,800 plants/ha. The soil type was Shamel silt loam, coarse-loamy, mixed, frigid, typic Haploxerolls.

A nitrogen fertilization study was superimposed on each strain in the planting. This consisted of 112 and 224 kg/ha nitrogen from NH_4NO_3 and 224 kg/ha of nitrogen from $(NH_4)_2S)_4$ replicated three times. Capsule harvests were made in 1977 and 1978. Thebaine yields are presented in table 8.

Table 8.--*Thebaine yields from fertilizer treatments, of* Papaver bracteatum *accessions at Warden, Wash.*

Fertilization rate (kg/ha)	Calculated thebaine yield[1]									
	PI 377953		PI 378940		PI 381600		PI 381607		PI 383309	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
	Kg/ha									
112 NH_4NO_3	8.4	10.1	18.6	23.2	13.8	17.1	18.1	22.8	23.0	25.9
224 NH_4NO_3	9.1	11.4	15.0	19.0	17.2	21.5	16.5	20.6	21.5	25.3
224 $(NH_4)_2SO_4$	15.0	18.5	14.1	16.7	16.4	19.5	13.0	15.8	17.8	20.9

[1]Average of 3 replications.

Thebaine percentages and capsule yield at Warden were similar to those obtained for the same accessions at Central Ferry. The results fail to justify the higher nitrogen application on Shamel soil. This is in agreement with the results obtained on Spofford soil at Central Ferry. *P. bracteatum*, native to the semidesert bunchgrass areas in Iran, is not a high fertility-requiring plant, nor does it respond to luxury feeding on nitrogen. A routine soil analysis was made on the Warden soil by the Washington State University Soil Testing Laboratory before establishing the planting, with the following results: pH, 7.5; organic matter, 0.9 percent; phosphorus, 19.4 p/m; potassium, 650 p/m; and salts, 0.25 mmhos/cm.

All plants were present and growing normally in October 1978, but the winter of 1978-79 was colder than usual with little snow cover. In May 1979, only 26 plants remained of the 1,200 established. These were in pockets and depressions where some snow cover protection was provided. Plantings of the same accessions at Central Ferry were not winterkilled. The primary difference was that no snow cover was present at Warden when the cold weather occurred, while at Central Ferry, a snow cover of 15 to 20 cm protected the plants.

Minimum temperatures at Central Ferry and Warden for December, January, and February 1975-79 are presented in table 9. Temperatures in these ranges, without snow cover for the extended period of about 90 days at Warden, appear to be too harsh for *P. bracteatum* survival. Temperatures of only a few degrees warmer, but with 15 to 20 cm snow cover, caused no damage to the Central Ferry plantings.

Frosts in April are a hazard. On April 20, 1977, the temperature dropped to -5°C at Central Ferry and all buds at or above the leaf mass were killed. By counts made at maturity, these barren, short stems made up 28 percent of the total stem counts. With the loss of terminal meristems, these stems failed to elongate further and remained at the 30- to 40-cm height. This contributed to the low yields of 1977.

Table 9.--*Minimum temperatures at Central Ferry and Warden, Wash., 1975 to 1979*

Central Ferry		Warden	
Date	°C	Date	°C
Dec. 12, 13, 14, 1975	-11.1	Dec. 14, 1975	-15.0
Jan. 2, 1976	-6.6	Jan. 10, 1976	-10.0
Dec. 4, 5, 1976	-7.7	Dec. 20, 1976	-11.6
Jan. 7, 8, 1977	-12.7	Jan. 5, 1977	-15.5
Dec. 31, 1977	-9.4	Dec. 31, 1977	-17.2
Jan. 2, 1978	-16.1	Jan. 1, 1978	-22.2
Dec. 31, 1978	-22.2	Dec. 29, 1978	-18.8
Jan. 1, 1979	-20.0	Jan. 1, 1979	[1]-24.4
Feb. 2, 3, 1979	-17.7	Feb. 1, 1979	-22.2

[1]High of 1°C on the 13th; only day in the month above freezing. Highest low was -7°C on the 21st.

ALKALOID DEVELOPMENT IN GERMINATING SEEDS

Seeds of *P. bracteatum* and *P. somniferum* were washed in 95 percent ethyl alcohol to remove any latex that might be on the surface and dried in an airstream. The seeds were divided into seven lots each, and one lot of each was analyzed immediately for alkaloids by the method presented in U.N. Document ST/-SOA/Ser.J/15, 1974. The remaining six seed lots were germinated on filter paper and moistened with distilled water in petri dishes. One lot of each was analyzed every 24 hr for the 6 days.

Germinating *P. somniferum* seeds began producing alkaloids within the first 24-hr sample period and continued to show strong alkaloid production throughout the 6-day period. This agrees with the general statement of Waller and Nowacki (*1978*, p. 140) that *Papaver* seeds commence the synthesis of alkaloids with the onset of germination.

The alkaloids of dominance at the end of the first 24-hr period were codeine, morphine, and papaverine. These were verified with available standards developed on thin-layer chromatograms. Germinating *P. bracteatum* did not follow this pattern. No alkaloid was obtained from the germinating seeds through the sixth day; however, whole seedlings grown in soil to the fully extended cotyledon stage (14 days from seeding) were found to contain thebaine. Correlation of these seedling levels with the thebaine levels found in the capsule tissues of the maternal parent showed an $r = +0.30$ for 110 pairs. This is significant at the 1-percent level (Snedecor *1956*).

Seedling thebaine is an indicator of the level of thebaine in the parent from which it came. Its value in predicting the ultimate alkaloid level has not been determined, but if the offspring reflect the maternal parent, 2-week-old seedling tissue should be a good index for the relative thebaine levels at maturity.

LANCING AND GUM COLLECTION

A study to determine the effect of lancing on total thebaine production was undertaken in 1978. Capsules were lanced with double cuts into the laticifers on 1/2 to 2/3 of the circumference of the capsule, allowed to bleed, and the dried latex was scraped from the capsule surface. The gum was collected from 200 capsules of PI 381607 when the capsules were 25 to 30 days from bud opening. The gum was stored in a refrigerator for 60 days in a snap-top plastic vial before analysis. Moisture content was 18 percent. The mass was firm, but still pliable. The gum contained 29.3 percent thebaine (dry weight basis). The lanced capsules were harvested at maturity and paired (1-1) with unlanced capsules harvested from the same plants. At maturity, the lanced capsule tissue still contained 2.5 percent thebaine, whereas the unlanced capsule tissue contained 2.9 percent thebaine.

The loss of 0.4 percent thebaine is about 80 g/ha. If capsules were regularly lanced, the total thebaine yield per unit area, based on the above figures, could be nearly doubled. Thebaine yield from gum could be about 16 kg/ha and from the lanced capsule, 20 kg/ha. The unlanced capsules could yield 23.2 kg/ha, a loss of only 3.2 kg/ha for lancing, but by collecting the gum, an increase in total thebaine of 12.8 kg/ha could be realized

POLLINATION

Papaver bracteatum is an almost obligate cross pollinated plant. Selfing is very rare. The prime pollinator is the common honeybee (*Aphis mellifera* L.), which apparently came from feral colonies in the area. Honeybees made up 90 percent of the insects collected when *P. bracteatum* was in full bloom. The other bees collected were *Halictus rubicundus* (Christ), 7 percent, and *Agtostemon* sp. prob. *virescens* (Fabr.), 3 percent. Other insects present were lygus bugs (*Lygus* sp.), lady bugs (*Adalia* sp.), and lacewings (*Hemerobius* sp.). Bees visiting poppy flowers are primarily pollen gathers (figs. 4 and 5) working among the anthers and over the stigmatic cap.

To determine whether thebaine might be present in the hive, we collected pollen directly from flowers, from the pollen baskets on honey bees' legs, and from whole bee bodies with filled pollen baskets, and analyzed each sample for thebaine. All results were negative.

In a pollination experiment with a colony of honeybees confined to a cage during flowering, honey was extracted from several frames and found to be free of thebaine. This colony was fed a diet of sugar and sirup water for maintenance. The pollen collected from the poppies during this period was distinguishable in the brood frames because the deep purple color of the pollen persisted in the cells. No thebaine was found in the pollen from these purple-pigmented cells.

Figure 4.--Honeybee gathering pollen.

Figure 5.--Honeybee laden with pollen alighting on an opening bud.

Selfing cages were set up over selected plants of all three species of *Papaver* (section Oxytona) at early bud stage. Each capsule in each cage was inspected microscopically at maturity for the number of normally developed seeds. Those capsules that received no pollination other than pollen from the same plant, produced fewer than 1 percent plump, normal-appearing seeds. These could have been pollinated by stray windblown pollen grains or pollen dropped by insects attempting to visit the unavailable flowers. Therefore, it cannot be assured that these few seeds resulted from self-pollination.

Those flowers pollinated by tranferring pollen from nonrelated clones, within the same species, regularly set at least 85 percent normal seeds. Attempted crosses between *P. bracteatum* x *P. orientale*, *P. bracteatum* x *P. pseudo-orientale*, and *P. orientale* x *P. pseudo-orientale* regularly failed. A few normal-appearing seeds were present only on rare occasions, usually less frequently than those observed in attempted selfed capsules. Normal-appearing, plump seeds produced normal, vigorous seedlings. This was true for the open pollinated capsules and those produced in the selfing cages by attempted interspecific crosses and selfs. These plants are being grown to maturity for evaluation.

SUMMARY AND CONCLUSIONS

Papaver bracteatum has been successfully established at Central Ferry and Warden by transplanting 6 to 8-week-old seedlings and by direct seeding in early fall and early spring. Plant survival and production of thebaine were satisfactory at Central Ferry, but recurring winter temperatures below -17°C, in the absence of snow cover, destroyed the planting at Warden.

Fertilizer applications to Spofford soil beyond 56 kg/ha N did not increase yield of capsules or of thebaine per unit area. There is limited evidence to indicate that $(NH_4)_2SO_4$ may be superior to NH_4NO_3 as a nitrogen source. Plant populations of 50,000 to 70,000 plants per hectare resulted in the higher yield of capsule tissues and thus the higher thebaine yield over a 4-year period. Thebaine content of capsule tissues less than 10 days from bud opening is high, but owing to the limited amount of dry matter present, the total thebaine produced per unit area is low. At maturity, the dry capsule (fig. 6) is more than 10 times larger than the juvenile capsule and the thebaine level in the capsule has increased to that of the young tissue, resulting in a total yield of more than 10 times the amount present at petal drop.

P. bracteatum is highly self sterile. Natural field pollination is accomplished by bees. Hand pollination results in more than 85 percent seed set. Attempted crosses between *P. bracteatum*, *P. pseudo-orientale*, and *P. orientale* were unsuccessful, even though all three species are in *Papaver* sect. Oxytona.

Thebaine is stable in whole dry capsules, but if the capsules are finely ground and stored, some loss of thebaine occurs. The loss of thebaine is greatly accelerated if seeds are ground with the capsule tissue before storage. Repeated sprinkler irrigation, simulating summer-type showers on standing mature capsules, did not reduce the thebaine content of the capsules.

Figure 6.--Mature capsules; note presence of bracts.

By lancing the capsule, collecting the gum, and then harvesting the same mature capsules for extraction, we can obtain almost double the total thebaine yield per unit area in comparison with the amount of thebaine obtained from the unlanced or intact capsules harvested at maturity.

Papaver bracteatum can produce thebaine for conversion to medicinally required products in quantities that could make production feasible in many irrigated areas of the Western United States. Further development of superior strains through breeding and selection is possible. Production and harvesting of capsule tissue is possible with little modification of existing, commonly used farm equipment (fig. 7). The processing and extraction processes are available within the pharmaceutical industry. Under our conditions, PI's 374719, 381438, 381442, 381457, 381444, 381487, 381488, 381490, 381492, 381493, 381494, 381495, 381497, 381502, and 381534 grew well and produced the higher amounts of thebaine on a calculated per-hectare basis.

The development of *P. bracteatum* into a domestic source of thebaine for conversion to codeine could make the United States self sufficient in codeine and related licit drugs. The initial work reported here and the germplasm now developed form a base for thebaine production and strain improvement should the need arise. *Papaver bracteatum* is capable of becoming a new crop for American agriculture. Further development of elite germplasm should be pursued.

Figure 7.--Harvesting poppy capsules with a small grain plot combine.

LITERATURE CITED

Goldblatt, P.
1974. Biosystematic studies on *Papaver* section Oxytona. Annals of the Missouri Botanical Garden 61:264-296.

Sharghi, H., and I. Lalezari.
1967. *Papaver bracteatum*, a highly rich source of thebaine. Nature 213:1244.

Silker, R. E., W. E. Shrenk, and H. H. King.
1944. Determination of carotene in alfalfa: a simplified method. Annals of Industrial and Engineering Chemistry 16:513-515.

Snedecor, G. W.
1956. Statistical methods. Fifth edition. Iowa State College Press, Ames, Iowa. 534 p.

United Nations.
1973. Scientific research on *Papaver bracteatum*. Document ST/SOA/Series J, number 2.

United Nations.
1974. Scientific research on *Papaver bracteatum*. Document ST/SOA/Series J, number 15.

Waller, G. R., and E. K. Nowacki.
1978. Alkaloid biology and metabolism in plants. Plenum press, New York. 294 p.

APPENDIX

Appendix table 1.--*Characterization of the first* Papaver *plant introduction (PI) accessions (section Oxytona) established at Central Ferry, Wash.*

PI NO.	Flower color	Stem	Rhizomes	Petal spot	Bracts	Apparent species[1]
374705	orange	semiscape	no	medium-dark	yes	Pseudo.
374708	red	cauline	no	variable	yes	Do.
374709	orange	semiscape	no	--do--	yes	Do.
374715	red	cauline	no	large-dark	yes	Bract.
374719	orange	semiscape	no	small-light	yes	Pseudo.
374720	--do--	scape	yes	none	no	Orient.
374817	red	semiscape	no	small-dark	yes	Pseudo.
374819	orange	--do--	no	light	no	Do.
374821	--do--	scape	no	none	no	Orient.
374822	--do--	--do--	yes	--do--	no	Do.
374823	--do--	--do--	yes	--do--	no	Do.
374824	--do--	--do--	yes	--do--	no	Do.
374826	--do--	--do--	yes	--do--	no	Do.
374827	--do--	--do--	yes	--do--	no	Do.
374834	red	semiscape	no	variable	yes	Pseudo.
374835	--do--	--do--	no	medium-dark	yes	Do.
374838	orange	--do--	no	none	yes	Do.
374839	red	cauline	no	large-dark	yes	Bract.
374844	orange	semiscape	no	none	yes	Pseudo.
374846	red	cauline	no	large-dark	yes	Bract.
374847	orange	semiscape	no	small-light	no	Pseudo.
374852	red	cauline	no	large-dark	yes	Bract.
374853	--do--	--do--	no	--do--	yes	Do.
374854	--do--	--do--	no	--do--	yes	Do.
374857	--do--	--do--	no	--do--	yes	Do.
374858	--do--	--do--	no	--do--	yes	Do.
375952	orange	semiscape	no	variable	yes	Pseudo.
375984	pink	cauline	no	--do--	yes	Do.
375985	orange	semiscape	no	--do--	yes	Do.
375986	pink	cauline	no	large-light	yes	Do.
376334	orange	semiscape	no	variable	yes	Do.
376808	--do--	--do--	no	medium	no	Do.
376809	--do--	--do--	no	variable	yes	Do.
376810	--do--	--do--	no	large-dark	yes	Do.
376811	--do--	--do--	no	medium	no	Do.
376812	--do--	--do--	no	--do--	yes	Do.
376813	--do--	--do--	no	variable	no	Do.
376814	--do--	--do--	no	medium-light	yes	Do.
376815	--do--	scape	yes	none	no	Orient.
376816	--do--	semiscape	no	variable	yes	Pseudo.
376817	--do--	--do--	no	--do--	yes	Do.

See footnote at end of table.

Appendix table 1.--*Characterization of the first* Papaver *plant introduction (PI) accessions (section Oxytona) established at Central Ferry, Wash.*--Continued

PI NO.	Flower color	Stem	Rhizomes	Petal spot	Bracts	Apparent species[1]
376819	orange	semiscape	no	none	no	Pseudo.
376820	--do--	--do--	no	variable	yes	Do.
376821	--do--	scape	yes	none	no	Orient.
376822	--do--	--do--	yes	--do--	no	Do.
376823	--do--	--do--	yes	--do--	no	Do.
376824	--do--	--do--	yes	--do--	no	Do.
376825	--do--	--do--	yes	--do--	no	Do.
376826	--do--	--do--	yes	--do--	no	Do.
376827	--do--	--do--	yes	--do--	no	Do.
376828	--do--	semiscape	no	variable	yes	Pseudo.
376829	--do--	--do--	no	--do--	no	Do.
376830	--do--	cauline	yes	large-dark	yes	Do.
377953	red	--do--	no	--do--	no	Bract.
378940	--do--	--do--	no	--do--	yes	Do.

[1]Bract. = *Papaver bracteatum* Lindl.
Orient. = *Papaver orientale* L.
Pseudo. = *Papaver pseudo-orientale* (Fedde) Medw. or *Papaver intermedium* DC. (syn).

Appendix table 2.--*The plant height, capsule production, capsule size, thebaine percentage, and calculated thebaine per hectare for 1976-79 in* Papaver bracteatum *plant introduction (PI) accessions*

PI No.	Plant height	Average number of capsules per plant				Average weight per capsule				Thebaine				Calculated thebaine			
	1976	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
	Cm					*Grams*				*Percent*				*Kg/ha*			
374703	70	3.5	4.8	8.8	8.4	2.9	0.7	1.1	1.4	1.6	---	1.8	0.9	5.7	---	7.0	3.8
374705[1]	58	2.3	2.0	8.0	4.1	2.9	.5	.6	.7	1.5	3.1	2.1	1.0	3.6	1.1	4.3	1.1
374709[1]	75	9.5	12.0	16.2	11.5	2.9	.8	.8	1.0	.4	1.3	1.9	1.1	4.2	5.1	10.1	4.9
374710	75	8.0	9.6	14.4	11.8	3.8	.9	1.1	1.1	2.1	3.0	2.7	1.1	22.5	10.2	16.7	5.6
374712	78	6.2	10.2	17.7	15.0	4.1	1.2	1.5	1.6	1.9	2.6	2.8	.8	16.9	12.0	22.7	9.6
374714	105	8.2	7.7	14.7	11.5	3.3	1.5	.7	1.6	1.8	1.8	2.5	1.1	32.8	8.3	10.7	7.4
374716	80	8.9	9.8	16.2	14.6	2.9	1.1	1.5	1.4	1.4	2.5	2.0	1.0	13.0	4.7	18.5	7.2
374717	63	7.8	---	22.2	14.4	3.2	---	1.1	1.4	1.2	1.8	1.7	.9	10.6	---	17.3	6.9
374719[1]	88	14.8	6.8	17.5	13.9	3.2	1.4	1.4	1.4	2.1	2.1	2.9	1.9	35.4	7.5	27.2	13.3
374721	100	8.7	7.8	13.6	12.7	---	1.2	1.8	1.7	1.0	2.2	1.9	.8	---	8.1	18.3	8.1
374834[1]	83	6.3	4.2	16.3	16.6	5.1	.7	1.5	1.4	1.9	2.1	1.6	1.7	21.7	2.5	15.6	16.8
374839	92	11.8	8.7	21.7	22.3	---	1.2	1.6	1.3	1.2	2.0	2.7	1.6	---	8.3	35.3	16.6
374845	84	14.4	8.4	18.8	17.8	2.6	.6	1.0	1.1	1.7	2.5	2.1	.9	23.0	4.2	15.6	6.6
374846	86	9.6	4.8	15.9	15.6	3.3	.6	1.0	1.0	1.1	2.3	2.1	.9	12.5	4.9	13.0	5.0
374847[1]	72	11.3	7.9	19.4	14.6	2.9	.8	1.0	1.3	2.1	2.0	1.9	.9	24.7	3.6	13.8	6.6
374852	80	7.5	9.2	21.1	21.8	4.7	1.7	1.5	1.3	1.4	2.3	1.8	1.4	17.4	13.9	21.5	11.7
374853	83	9.2	7.1	16.9	14.1	---	1.4	1.5	1.3	1.8	1.8	2.5	1.2	---	7.0	25.1	8.1
374854	68	9.8	10.1	19.1	15.9	3.2	1.6	1.4	1.3	2.4	1.9	2.9	1.5	26.5	12.1	31.1	11.1
374855	70	6.1	2.0	10.2	13.2	3.7	.7	1.4	1.0	3.2	.9	2.2	1.4	26.3	.5	12.1	1.6
374857	86	9.0	9.2	15.1	15.8	3.6	1.4	1.2	1.4	---	2.3	1.5	1.4	---	11.3	10.9	10.9
374858	93	6.2	4.7	10.1	10.6	4.6	1.1	1.5	1.2	.8	1.8	1.6	1.2	8.2	3.6	9.6	5.5
381438	78	10.6	5.2	15.2	15.0	3.3	1.3	1.4	1.3	2.3	2.4	2.5	1.7	28.8	5.1	20.2	11.5
381439	83	9.1	4.1	11.9	12.7	3.9	1.6	1.4	1.6	1.5	2.7	2.5	1.8	20.4	6.9	16.5	13.5
381440	64	6.7	3.8	12.0	12.5	4.4	.6	1.5	1.5	2.9	2.3	1.2	1.7	30.0	2.1	8.4	11.4
381441	70	10.7	8.9	13.0	11.6	4.3	1.1	1.9	2.0	1.6	2.2	2.3	1.4	26.3	8.5	22.3	12.0
381442	74	12.7	9.8	16.8	17.6	3.9	1.1	1.3	1.6	2.0	2.4	2.9	2.1	35.7	10.6	23.7	21.7
381443	88	9.3	5.3	14.4	12.2	3.7	.6	1.2	1.5	1.5	2.3	1.4	1.9	18.1	2.7	9.6	12.7
381444	82	13.3	8.3	15.7	15.6	3.7	1.0	1.4	1.5	2.2	2.1	1.8	1.9	38.5	6.4	16.0	16.7
381445	80	9.9	7.0	15.7	15.4	3.1	.8	1.5	1.7	1.6	2.2	1.8	2.5	17.7	5.1	16.5	15.5
381446	76	10.7	4.1	13.2	10.8	3.5	.8	1.3	1.8	1.6	2.9	1.5	---	21.7	3.8	10.0	---
381447	75	4.7	4.7	10.3	3.2	3.6	1.2	1.1	1.3	2.5	3.4	1.6	2.9	15.2	7.5	7.2	4.3
381448	94	8.6	6.6	13.0	11.1	3.8	1.5	1.7	1.8	2.8	2.2	2.7	2.3	24.8	8.6	22.8	13.4
381449	74	6.6	3.7	12.2	13.3	4.6	.8	1.5	1.6	1.8	2.5	1.4	2.0	19.2	3.0	9.7	14.9
381450	63	2.7	4.0	6.1	8.4	3.6	.9	1.1	1.3	3.5	2.5	1.9	2.7	12.4	3.6	4.9	10.9
381451	66	4.4	3.9	7.8	8.0	4.4	1.5	1.5	1.5	2.2	2.5	3.0	2.5	14.9	5.6	13.7	11.2
381452	82	4.8	6.0	12.0	10.0	5.1	1.5	1.7	1.8	1.6	2.9	1.4	2.0	13.6	9.7	10.8	6.7

See footnote at end of table.

Appendix table 2.--*The plant height, capsule production, capsule size, thebaine percentage, and calculated thebaine per hectare for 1976-79 in* Papaver bracteatum *plant introduction (PI) accessions*--Continued

PI No.	Plant height	Average number of capsules per plant				Average weight per capsule				Thebaine				Calculated thebaine			
	1976	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
	Cm					*Grams*				*Percent*				*Kg/ha*			
381453	71	---	6.0	10.1	11.3	---	1.3	1.3	1.4	---	2.3	1.2	2.2	---	6.6	6.4	12.4
381454	71	8.3	6.0	14.0	10.2	3.0	.7	1.0	1.4	2.8	3.3	1.4	1.9	24.9	5.2	7.7	9.9
381455	80	9.7	4.6	11.6	10.3	3.3	.5	1.2	1.4	1.9	2.3	1.5	1.4	21.7	2.8	8.3	7.6
381456	62	2.7	3.7	8.7	11.2	3.9	---	1.4	1.6	1.1	2.7	1.5	1.4	3.9	---	3.6	3.8
381457	72	10.1	3.7	20.3	17.3	3.8	.6	1.6	1.8	2.2	2.6	1.1	1.7	30.7	7.4	14.1	19.9
381458	64	8.2	11.6	13.7	11.3	4.6	.8	1.8	1.2	2.2	2.7	1.9	1.6	29.1	4.4	18.2	14.0
381459	74	9.8	5.0	12.2	15.6	3.4	1.3	1.5	1.6	2.7	2.4	2.0	1.8	35.7	10.0	14.3	13.5
381460	72	7.7	8.2	15.1	15.0	4.3	1.3	1.3	1.6	1.5	2.2	1.2	1.0	16.0	9.8	9.3	8.6
381461	63	3.8	9.0	7.0	7.0	3.1	---	.8	.9	2.3	2.4	2.3	1.4	8.9	---	4.8	3.3
381462	85	8.0	6.4	13.2	13.5	3.9	.9	1.4	1.4	1.6	2.3	1.9	1.3	17.7	5.3	13.4	9.2
381463	75	7.3	5.6	13.6	10.4	4.2	.7	1.6	1.8	2.7	3.5	1.4	1.2	29.9	5.4	12.2	9.3
381464	85	8.4	3.9	12.8	11.8	4.5	1.1	1.6	1.8	1.3	3.2	1.5	1.2	17.1	5.2	11.9	2.7
381465	70	5.1	2.4	9.9	5.3	3.4	1.1	1.2	1.2	2.6	1.3	1.8	1.6	15.8	1.3	8.4	8.6
381466	78	5.9	3.1	10.1	10.7	3.4	.7	1.3	1.4	1.9	3.2	1.3	1.2	13.5	2.8	6.3	6.9
381467	84	4.4	1.3	8.4	10.9	3.0	---	1.4	1.5	1.9	---	1.3	1.2	10.8	---	6.0	6.9
381468	96	7.4	4.3	11.4	11.6	5.1	.7	1.5	1.9	1.5	3.6	1.5	1.1	20.4	4.2	9.9	9.5
381469	81	7.1	2.3	11.4	9.8	3.7	---	1.3	1.6	1.8	---	1.3	1.1	16.7	---	7.6	6.4
381470	86	5.0	6.7	12.7	11.0	4.6	1.5	1.8	2.1	1.6	3.9	1.1	1.0	12.6	14.7	9.6	8.2
381471	88	9.8	5.1	10.5	11.3	4.2	1.2	1.6	1.8	1.9	3.6	1.9	.9	27.8	9.2	12.7	6.7
381472	88	7.3	.9	10.6	11.1	3.2	---	1.4	1.5	1.8	--	1.9	.6	19.9	---	10.7	6.6
381473	100	7.6	2.0	11.7	11.7	4.0	---	1.3	1.3	1.4	---	2.2	.7	15.0	---	13.0	6.7
381474	88	7.5	5.6	10.8	11.1	4.9	1.3	1.6	1.7	2.3	3.3	2.9	.9	30.3	9.0	19.6	6.2
381475	68	6.3	---	8.5	7.2	4.1	---	1.6	1.8	1.2	---	1.9	.8	11.0	---	10.1	3.6
381476	80	10.4	6.8	11.9	13.3	3.9	1.1	1.6	1.6	1.7	2.8	2.8	.9	24.8	8.4	20.4	6.8
381477	70	5.5	1.0	10.0	9.4	3.2	---	1.0	1.1	1.6	2.7	3.2	.8	10.2	---	12.2	2.8
381478	75	4.6	2.9	9.5	9.7	3.8	.6	1.5	1.5	1.6	3.1	2.8	.9	9.6	2.3	15.1	4.9
381479	80	8.1	4.0	11.6	10.5	4.2	1.3	1.5	1.9	1.7	3.0	2.5	.8	20.6	5.9	16.7	5.7
381480	76	6.0	1.5	9.3	4.8	3.8	---	1.5	1.5	1.2	2.8	2.5	.7	10.6	---	13.0	1.4
381481	90	5.1	---	7.7	6.8	4.1	---	.9	1.4	.4	---	1.7	1.3	3.6	---	4.5	4.4
381482	96	8.5	---	11.3	7.4	2.0	---	.9	1.1	3.0	---	2.7	1.3	18.1	---	11.1	3.7
381483	84	5.8	---	9.6	5.9	2.7	---	1.3	1.0	1.4	---	2.3	1.2	7.9	---	10.8	2.5
383484	93	8.4	6.7	9.8	15.6	2.9	---	1.3	1.2	1.6	3.7	2.8	1.6	14.2	---	13.6	3.4
381485	86	9.4	6.7	10.3	14.4	3.3	1.0	1.2	1.3	1.4	3.5	2.2	.9	17.0	8.9	10.3	6.1
381486	94	10.4	5.5	11.1	12.1	2.5	.6	1.3	1.5	1.8	2.9	2.0	1.0	16.7	7.5	11.3	6.4
381487	86	10.9	3.0	11.7	11.7	3.6	.6	1.1	1.7	3.5	3.2	3.3	2.3	48.8	3.9	16.1	18.0
381488	100	12.0	7.3	12.7	12.6	3.3	.5	1.3	1.7	3.6	3.7	3.6	1.1	51.1	1.7	23.2	8.6

381489	93	11.0	8.0	12.3	11.0	3.9	1.1	1.5	2.0	1.8	1.8	3.3	2.2	27.6	11.6	24.3	17.7
381490	97	11.3	8.3	14.1	12.1	3.8	1.1	1.4	1.8	2.2	2.1	3.0	1.6	33.8	6.1	22.5	12.7
381491	74	8.7	6.0	12.4	10.8	3.4	.8	1.1	1.1	2.7	1.7	3.4	2.4	28.0	5.7	17.9	10.2
381492	92	13.6	14.4	10.0	15.7	3.9	1.1	1.5	1.7	2.5	3.4	3.8	2.8	47.4	---	35.5	24.3
381493	87	11.4	2.7	10.1	11.1	3.9	1.0	1.7	1.7	2.0	2.2	2.6	1.7	32.1	2.3	17.2	11.9
381494	77	11.4	2.5	10.2	12.3	3.8	.8	1.5	1.5	2.4	1.2	2.5	1.2	36.8	.9	14.9	8.9
381495	90	12.9	3.6	12.1	11.9	3.5	1.0	1.3	1.5	3.2	3.5	2.2	2.7	54.7	4.6	13.4	17.1
381496	90	10.2	3.8	13.6	11.0	3.4	.5	1.2	1.6	2.5	1.7	3.5	2.1	31.2	1.3	14.7	13.0
381497	88	10.0	2.7	13.4	11.8	2.8	---	1.1	1.5	4.2	1.6	3.3	2.3	46.0	---	19.1	14.5
381498	76	7.2	2.1	7.1	9.1	3.3	---	1.4	1.7	1.6	1.4	2.4	1.9	13.6	---	5.8	10.4
381499	84	8.7	5.1	8.4	7.3	4.0	1.3	1.6	2.0	2.7	1.9	2.2	2.0	32.8	4.9	11.2	10.9
381500	82	9.3	5.0	7.7	10.1	4.0	1.5	1.7	1.9	1.6	1.7	2.8	2.5	21.1	3.6	14.4	17.5
381501	92	10.2	5.8	8.7	8.1	4.5	1.4	1.4	1.7	1.8	1.3	2.8	2.7	27.0	4.0	13.1	13.2
381502	80	11.0	9.3	13.8	12.8	3.5	1.2	1.4	1.4	2.7	1.2	2.7	1.5	36.6	5.5	19.5	10.0
381503	76	7.5	5.6	10.5	10.7	3.8	1.0	1.5	1.7	2.3	1.8	3.2	2.1	23.8	4.0	19.5	13.8
381504	71	6.2	5.3	11.3	10.2	3.8	1.0	1.3	1.2	3.5	1.2	3.8	1.5	30.0	2.3	21.5	16.9
381505	80	9.0	1.8	9.8	8.3	3.2	---	1.4	1.5	2.1	1.2	2.3	1.9	23.5	---	12.7	9.0
381506	86	8.3	1.2	10.2	11.7	3.3	---	1.4	.8	1.8	2.2	2.5	2.2	17.3	---	14.3	7.7
381507	96	7.0	4.2	10.3	10.1	4.0	1.0	1.4	1.6	3.6	2.3	2.5	2.5	35.9	2.5	14.4	14.7
381508	86	6.0	3.3	9.4	8.7	4.8	.8	1.6	.6	2.0	1.9	2.2	1.9	21.0	2.7	12.9	4.1
381509	84	7.2	7.4	9.9	11.5	3.5	1.3	1.4	1.5	2.7	1.7	3.0	2.0	24.1	6.3	16.6	13.1
381510	81	8.7	6.7	8.3	11.5	3.8	1.0	1.4	1.4	2.3	1.4	3.0	1.9	27.1	3.7	13.1	11.4
381511	100	12.5	9.9	10.5	11.2	3.9	1.2	1.4	1.6	1.9	1.8	3.5	2.2	33.2	8.2	19.7	14.4
381512	86	10.8	10.4	9.4	10.2	3.8	1.2	1.4	1.8	1.4	1.6	3.5	2.1	20.5	8.2	17.6	14.1
381513	92	9.0	5.6	10.1	9.4	4.6	1.4	1.6	1.7	1.8	2.6	3.2	1.7	26.3	7.6	19.7	9.8
381514	85	9.8	6.5	8.6	10.0	4.6	1.3	1.7	1.8	---	1.6	3.2	2.1	---	4.4	17.7	13.6
381515	85	11.1	5.7	11.2	12.0	4.1	1.1	1.3	1.5	1.7	1.5	3.2	1.2	27.3	3.5	18.2	7.6
381516	82	7.7	9.1	9.9	10.0	4.1	1.5	1.5	1.8	2.8	1.7	2.8	1.1	24.7	8.9	16.0	7.1
381517	88	7.6	5.9	9.1	9.2	4.3	1.0	1.6	1.8	1.6	1.5	2.7	1.2	20.0	3.4	14.9	6.9
381518	86	6.2	---	7.1	7.8	4.5	---	1.4	1.4	2.4	---	3.8	1.6	25.5	---	14.1	5.1
381519	90	5.0	2.0	7.4	8.6	4.2	---	1.4	1.5	2.1	2.0	3.5	1.5	16.7	---	14.3	7.0
381520	92	7.3	2.6	9.2	9.2	3.9	---	1.5	1.7	2.9	2.0	3.0	.9	30.8	---	16.0	5.0
381521	93	7.4	2.0	9.8	7.6	3.9	---	1.2	1.3	2.3	2.1	2.3	.9	25.3	---	10.7	5.5
381522	88	6.1	5.1	10.3	8.8	4.4	1.1	1.7	1.4	1.4	1.4	2.9	1.1	13.7	3.0	17.9	4.7
381523	77	7.8	8.2	10.0	13.7	3.3	1.1	1.6	1.2	3.5	1.8	2.1	1.4	34.5	6.1	13.4	8.2
381524	70	6.0	4.6	10.3	6.9	4.0	1.6	1.6	1.7	2.7	2.0	2.3	1.3	24.5	5.5	14.3	5.5
381525	76	6.4	---	9.2	6.8	4.0	---	1.6	1.6	2.4	3.0	2.3	1.7	29.1	---	9.6	7.4
381526	73	5.0	1.9	8.1	6.8	4.5	---	1.6	1.7	1.6	1.7	2.3	1.8	13.3	---	11.8	7.5
381527	78	6.4	1.5	7.1	7.0	3.5	---	1.1	1.2	2.7	1.6	2.5	1.6	22.5	---	7.6	4.9
381528	82	5.0	1.8	8.0	6.5	5.3	---	1.4	1.5	4.3	1.9	2.4	2.1	48.4	---	10.1	7.2
381529	76	5.9	1.8	9.1	5.0	4.0	---	1.5	1.3	2.9	1.4	2.6	2.0	26.4	---	12.3	4.9
381530	86	6.1	5.8	11.2	7.0	4.7	1.2	1.3	1.6	2.1	2.6	2.3	2.1	23.0	7.3	11.3	9.1
381531	78	5.6	7.5	7.9	7.9	4.8	1.4	1.3	1.6	2.2	1.6	2.7	2.2	22.5	6.4	10.6	9.8
381532	100	8.2	4.4	9.1	9.2	3.7	1.2	1.2	1.3	2.5	1.2	2.5	1.6	28.4	3.0	10.7	6.7
381533	86	7.0	5.8	7.3	6.9	3.7	1.1	1.5	1.3	2.4	2.1	2.9	1.3	14.4	5.1	11.8	4.0
381534	85	11.4	6.4	13.6	10.1	3.5	.9	1.5	1.3	1.8	2.1	2.6	1.7	26.6	4.7	13.7	7.6
381535	84	8.1	9.8	11.6	10.2	3.9	1.2	1.5	1.5	3.1	1.6	2.5	2.0	40.0	7.3	16.8	10.5
381536	88	7.6	7.2	10.3	8.6	4.0	1.1	1.4	1.4	1.6	1.7	2.6	1.8	17.1	5.5	14.3	7.9
381537	79	7.0	---	9.4	7.0	4.1	---	1.7	1.7	2.5	2.3	2.7	1.5	25.8	---	16.9	6.5

See footnote at end of table.

Appendix table 2.--*The plant height, capsule production, capsule size, thebaine percentage, and calculated thebaine per hectare for 1976-79 in* Papaver bracteatum *plant introduction (PI) accessions--Continued*

PI No.	Plant height	Average number of capsules per plant				Average weight per capsule				Thebaine				Calculated thebaine			
	1976	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
	Cm					*Grams*				*Percent*				*Kg/ha*			
381538	88	8.9	7.7	9.2	7.3	2.9	---	1.1	1.3	2.9	1.4	2.1	1.8	26.9	---	8.5	6.2
381539	86	9.1	1.6	9.7	7.1	3.5	---	1.3	1.5	3.0	1.3	2.0	1.3	34.3	---	10.2	5.1
381540	73	8.2	2.8	10.3	9.1	3.9	.8	1.4	1.6	3.1	2.2	2.2	1.8	35.7	1.9	12.7	9.6
381541	82	7.9	1.8	8.3	7.4	2.9	---	.9	1.6	1.9	---	2.8	1.3	15.5	---	7.5	6.4
381542	80	7.0	4.3	11.4	10.7	3.8	1.0	1.6	1.5	2.5	2.0	2.1	2.1	23.2	2.5	14.6	12.0
381543	89	6.9	4.1	10.0	8.0	3.7	.8	1.2	1.5	3.9	2.2	2.2	2.3	24.8	2.6	10.8	10.3
381544	78	8.5	3.9	9.1	7.3	4.0	.5	1.3	1.8	2.6	2.0	2.8	1.7	31.6	1.6	13.5	8.2
381545	80	7.2	5.4	7.6	7.9	3.1	1.2	1.2	1.1	3.3	1.5	2.9	1.9	25.8	3.9	10.4	5.8
381546	80	7.0	8.1	8.6	8.7	3.8	1.5	1.5	1.7	1.9	2.0	2.0	1.9	18.2	9.6	9.9	9.9
381547	77	6.7	8.8	---	7.5	2.8	1.1	---	1.2	1.2	1.2	---	1.0	8.0	4.6	---	6.1
381548	85	7.8	7.1	10.4	10.0	3.1	1.0	1.0	1.2	2.2	1.6	2.0	1.0	18.8	4.5	12.5	4.3
381549	70	10.6	7.3	13.1	15.2	2.4	.7	.9	1.2	1.4	1.9	1.2	.8	12.4	4.1	5.6	5.2
381550	78	11.2	10.8	12.1	10.7	2.4	.8	.9	1.1	2.9	2.1	2.7	1.7	28.0	8.8	10.7	7.1
381551	80	8.6	2.9	6.8	9.4	3.3	---	.8	1.2	2.1	1.7	2.1	1.0	20.9	---	4.5	3.9
381552	72	---	4.0	10.2	9.8	---	.8	.8	.9	---	1.7	1.6	.8	---	2.0	4.8	2.7
381553	86	---	5.9	11.2	9.3	---	.7	.6	.8	---	1.0	1.6	.5	---	1.6	4.5	2.3
381554	86	11.2	6.5	10.6	8.7	2.7	.8	.9	1.2	1.6	1.8	2.7	1.0	17.1	3.6	9.7	4.0
381555	--	---	7.8	9.3	10.6	---	.7	.9	1.0	---	8.1	7.5	4.0	---	2.0	2.3	1.0
381556	79	8.3	7.5	10.9	8.7	2.6	1.2	1.0	1.1	.7	1.3	2.2	.8	5.4	4.7	9.3	2.8
381557	74	7.3	5.6	9.0	7.9	2.4	.7	.7	.9	1.8	1.5	2.4	1.1	12.7	2.4	5.8	2.9
381558	70	6.9	8.2	8.8	4.9	3.3	1.2	.7	1.1	1.0	1.5	2.3	1.0	8.1	4.0	5.9	2.9
381559	90	8.8	9.1	8.6	6.8	3.3	1.0	.9	1.2	1.6	1.5	2.3	.8	12.7	5.6	7.2	2.4
381560	68	8.8	5.1	10.4	6.9	2.8	.5	.8	1.3	1.1	1.6	2.4	1.0	9.7	1.6	7.6	2.6
381561	89	11.8	10.0	8.8	9.6	---	.8	1.0	1.3	1.1	1.3	2.7	1.2	---	4.2	8.9	5.3
381562	80	11.2	6.4	---	10.7	3.5	1.1	---	1.2	1.2	1.8	---	.9	16.7	4.9	---	4.3
381564	--	---	8.7	10.3	11.0	---	---	.9	1.0	---	---	2.4	1.2	---	---	15.4	4.9
381565	70	10.0	5.9	11.1	10.2	2.6	.9	.8	1.1	1.6	1.4	2.8	1.0	14.7	2.9	8.8	4.0
381566	68	---	3.7	11.0	7.6	---	.6	.9	1.0	1.1	1.6	2.0	1.8	---	1.3	6.1	5.5
381567	75	10.6	5.1	10.7	10.3	---	.8	1.0	1.3	.7	1.4	3.1	1.2	---	2.2	12.8	5.7
381568	87	7.3	6.8	9.2	10.1	---	.7	.9	1.0	1.3	1.8	3.3	1.2	---	3.7	11.1	4.5
381569	84	9.0	8.4	8.1	11.5	2.6	.6	.8	1.1	1.7	2.0	3.1	1.6	14.5	4.2	8.4	7.2
381570	82	7.8	2.3	7.0	8.4	2.4	---	.9	.9	1.9	1.3	2.8	1.7	13.5	---	6.1	4.6
381571	74	4.8	3.2	9.7	6.1	2.4	.6	1.0	1.1	2.2	2.3	3.1	1.7	10.9	1.8	11.4	4.0
381572	80	6.7	11.0	11.8	10.3	2.6	1.2	.9	1.2	1.8	2.2	2.8	1.1	10.8	11.0	11.7	5.1
381573	60	5.8	7.4	---	6.1	---	1.0	---	1.2	1.8	1.6	---	1.4	---	4.7	---	3.9
381574	72	8.5	8.9	7.6	9.4	2.6	1.0	.9	1.2	2.6	1.7	2.1	1.1	20.4	5.7	5.4	4.4

381575	64	4.6	3.8	10.1	7.7	2.5	---	.7	.8	2.9	1.7	3.0	1.7	11.3	---	7.6	3.9
381576	70	4.5	4.2	12.5	13.5	4.3	---	.6	1.0	2.0	---	3.0	1.1	14.2	---	9.0	5.2
381577	86	8.0	4.8	8.4	11.2	3.1	---	.9	1.2	2.2	---	3.2	1.2	28.5	---	8.7	6.4
381578	86	4.5	7.5	13.0	15.0	4.8	---	1.5	1.4	1.6	---	2.7	1.1	8.5	---	9.9	8.3
381579	76	8.0	8.5	7.8	17.0	3.0	1.5	.8	1.2	1.6	1.2	1.2	1.5	13.6	5.7	3.0	10.7
381581	88	6.1	---	8.9	9.3	4.1	---	1.3	1.6	1.9	---	2.0	1.3	16.5	---	9.1	7.1
381591	65	3.2	3.5	5.4	12.2	4.9	1.6	1.5	1.8	1.6	1.6	2.2	1.0	8.5	3.4	6.6	9.3
381597	87	6.8	11.1	13.0	9.6	4.0	1.4	1.2	1.7	.7	2.4	2.1	1.4	6.7	15.0	13.4	8.2
381598	90	3.0	1.4	---	13.0	5.6	---	---	1.6	2.3	---	2.0	1.5	13.9	---	---	11.9
381599	90	8.6	5.6	4.8	9.3	3.6	1.0	1.1	1.8	1.7	1.5	1.4	.9	18.8	3.6	2.9	5.7
381600	75	5.4	6.7	9.2	9.1	3.8	1.7	1.6	1.6	3.0	2.0	2.9	2.3	21.4	8.6	16.0	13.7
381601	82	6.3	10.2	9.1	8.4	3.2	1.6	1.5	2.0	1.3	1.1	1.8	1.2	12.1	7.1	9.5	7.1
381602	90	7.0	13.5	9.4	9.0	4.4	1.1	.9	1.5	2.2	1.1	1.2	.9	22.4	8.9	5.5	4.3
381603	62	6.6	6.4	9.1	7.8	2.3	.6	.8	1.0	1.2	1.1	1.2	1.2	11.2	1.8	3.5	3.6
381604	65	6.1	6.8	11.6	10.1	6.1	1.3	1.6	1.5	3.0	2.5	2.4	1.8	37.3	8.9	16.7	10.0
381605	86	5.5	7.7	12.2	14.5	5.0	1.6	1.3	1.3	1.2	1.7	1.6	1.5	32.9	8.2	9.4	10.3
381606	82	8.8	12.4	15.1	14.9	3.8	1.6	1.4	1.6	2.2	2.7	2.4	1.4	25.8	19.8	20.2	8.4
381607	87	8.4	10.4	14.3	13.8	---	1.6	1.6	1.6	1.5	2.0	2.3	1.4	23.0	13.6	20.5	11.1
386097	76	6.1	6.1	15.1	8.9	4.2	1.6	1.7	2.0	2.1	2.2	1.4	1.7	18.7	8.3	13.7	10.6
391686	86	9.0	7.4	16.7	11.6	4.1	1.6	1.4	1.3	2.1	---	2.9	---	27.8	---	26.4	---
391687	70	7.8	8.1	15.0	14.6	3.8	1.3	1.5	1.5	1.6	1.6	2.6	1.5	17.1	6.4	22.8	11.8
391688	80	6.9	9.0	---	10.1	4.5	1.7	1.7	2.0	2.8	1.9	2.6	2.9	34.6	10.9	20.6	12.4
391689	80	7.4	11.6	---	12.6	3.2	1.2	1.0	1.4	1.7	1.0	1.9	1.0	14.5	5.8	10.3	5.6

[1]Listed as *Pseudo-orientale* in table 1.
Note: Dashes indicate missing data.

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WESTERN REGION
1333 BROADWAY, SUITE 400
OAKLAND, CALIFORNIA 94612

Return the mailing label(s) to above address if:

- ☐ Your name or address is wrong (indicate corrections, including ZIP)
- ☐ You receive duplicate copies (include labels from all copies received)
- ☐ You do NOT wish to continue receiving this technical series.